Natural Conditions Assessment for low pH and DO Morris Creek and Gunns Run, Charles City County, Virginia

Submitted by

Virginia Department of Environmental Quality

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Executive Summary

This report presents the assessment of whether low dissolved oxygen (DO) and low pH in Morris Creek and Gunns Run are due to natural conditions or whether a Total Maximum Daily Load (TMDL) must be performed because of anthropogenic impacts. Morris Creek and Gunns Run are located in Charles City County, VA in the James River Basin (USGS Hydrologic Unit Code 02080206). The waterbody identification code (WBID, Virginia Hydrologic Unit) for Morris Creek is VAP-G08R-01, and for Gunns Run is VAP-G03R-01. There are 27.11 stream miles in the Morris Creek watershed and 16.58 stream miles in the Gunns Run watershed. The impairments are for low DO and low pH in both watersheds.

The Morris Creek watershed is approximately 13,029 acres in size and is predominately forested (72.9 percent). Agriculture encompasses 7.7 percent of the watershed, with 3.6 percent cropland and 4.1 percent pasture/hayland. Residential and high use industrial areas compose approximately 0.1 percent of the land base. The remaining 19.3 percent of the watershed is comprised of 1.7 percent transitional areas and grasses, and 17.6 percent wetlands and open water. The impaired segment is 7.72 stream miles from the headwaters the head of tide near rivermile 5.97.

The Gunns Run watershed is approximately 6,607 acres in size and is predominately forested (64.5 percent). Agriculture encompasses 32.3 percent of the watershed, with 16.3 percent cropland and 16 percent pasture/hayland. Residential and high use industrial areas compose approximately 0.2 percent of the land base. The remaining 3 percent of the watershed is comprised of 3 percent wetlands and open water. The impaired segment is 8.30 stream miles from the headwaters the head of tide near rivermile 2.64.

Morris Creek and Gunns Run were listed as impaired on Virginia's 1998 303(d) Total Maximum Daily Load Priority List, the 2002 Impaired Waters Report and 2004 305(b) / 303(d) Integrated Report (VADEQ, 1998, 2002 & 2004) due to violations of the State's water quality standards for dissolved oxygen and pH.

In Morris Creek, a total of 70 DO data points, with 35 water quality standard violations (50%), were taken by DEQ at station 2-MOC005.97 from January 17, 1990 through November 15, 2006 (Figure E1). A total of 75 pH data points, with 28 water quality standard violations (37%), were taken by DEQ at station 2-MOC005.97 during this period (Figure E2).

Figure E1. Time series of DO Concentrations at Morris Creek at Rt. 623, 2-MOC005.97.

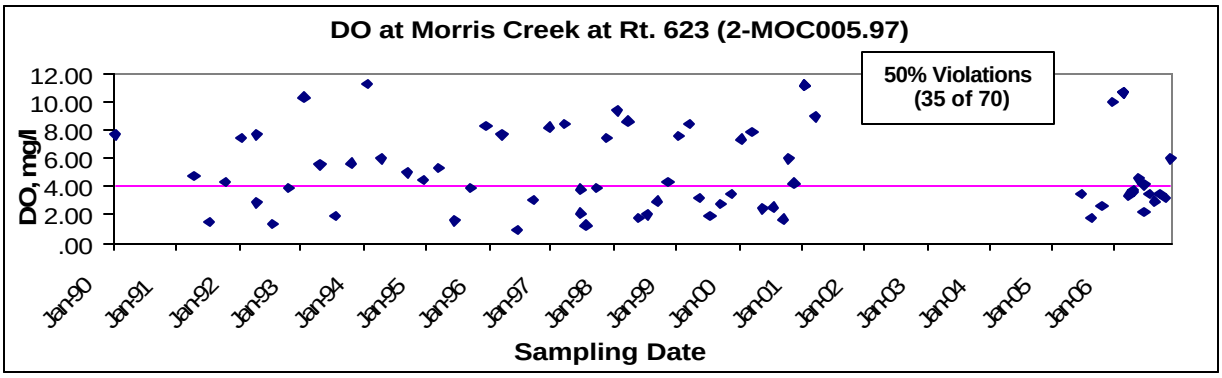
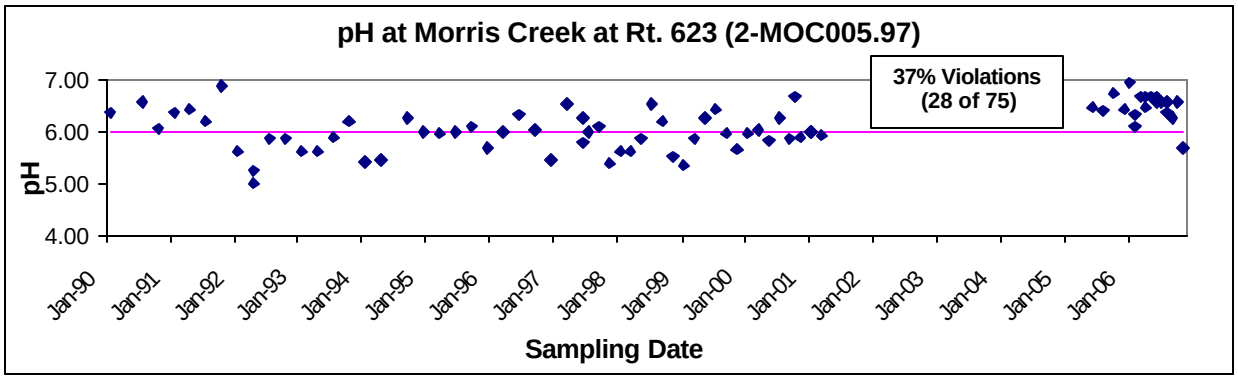


Figure E2. Time series of pH Concentrations at Morris Creek at Rt. 623, 2-MOC005.97



In Gunns Run, a total of 63 DO data points, with 12 water quality standard violations (19%), were taken by DEQ at station 2-GUN004.00 from January 17, 1990 through April 27, 2005 (Figure E3). A total of 66 pH data points, with 49 water quality standard violations (74%), were taken by DEQ at station 2-GUN004.00 during this period (Figure E4).

Figure E3. Time series of DO Concentrations at Gunns Run at Rt. 618, 2-GUN004.00.

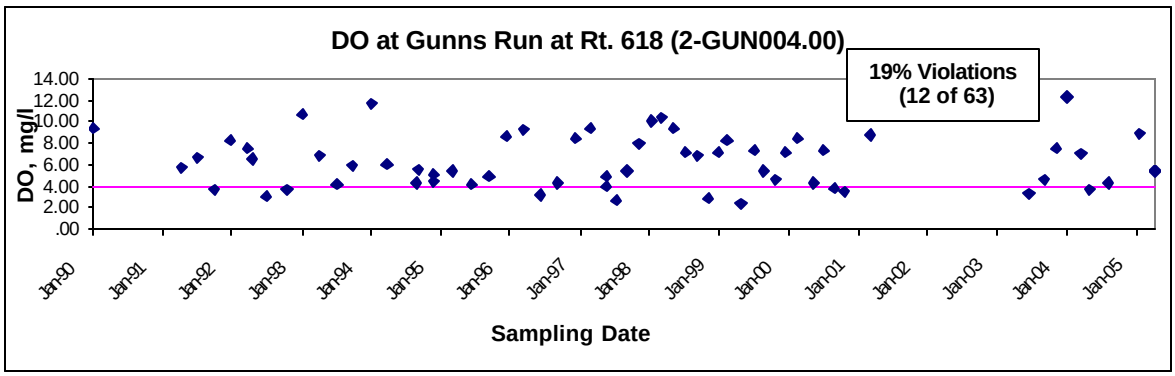
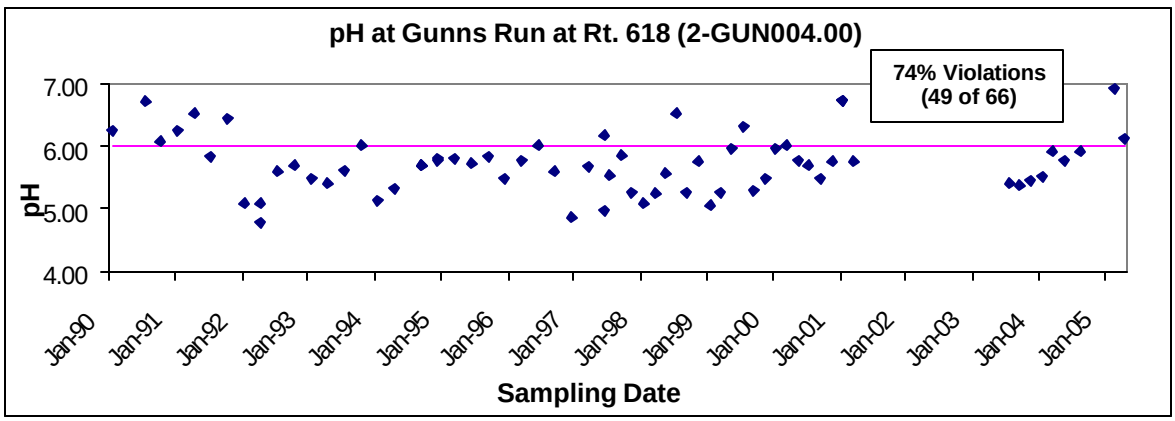


Figure E4. Time series of pH Concentrations at Gunns Run at Rt. 618, 2-GUN004.00.



According to Virginia Water Quality Standards (9 VAC 25-260-10A), “all state waters are designated for the following uses: recreational uses (e.g., swimming and boating); the propagation and growth of a balanced indigenous population of aquatic life, including game fish, which might be reasonably expected to inhabit them; wildlife; and the production of edible and marketable natural resources (e.g., fish and

shellfish)." As indicated above, Morris Creek and Gunns Run must support all designated uses and meet all applicable criteria.

VADEQ proposes a methodology for determining whether low DO originates from natural or anthropogenic sources, adapted from "Methodology for Assessing Natural Dissolved Oxygen and pH Impairments: Application to the Appomattox River Watershed, Virginia." (MapTech 2003)

The level of dissolved oxygen in a water body is determined by a balance between oxygen-depleting processes (*e.g.*, decomposition and respiration) and oxygen restoring processes (*e.g.*, aeration and photosynthesis). Certain natural conditions promote a situation where oxygen-restoring processes are not sufficient to overcome the oxygen- depleting processes. Conditions in a free-flowing stream that would typically be associated with naturally low DO include slow-moving, ripple-less waters where the bacterial decay of organic matter depletes DO at a faster rate than it can be replenished. Indicators of these conditions include low slope, the presence of wetlands, and often low pH due to organic acids (tannins, humic and fulvic substances) produced in the decay process.

These situations can be compounded by anthropogenic activities that contribute excessive nutrients or readily available organic matter to these systems. The general approach to determine if DO and pH impairments in free-flowing streams are due to natural conditions is to assess a series of water quality and hydrologic criteria to determine the likelihood of an anthropogenic source. A logical 4-step process for identifying natural conditions that result in low DO and/or pH levels and for determining the likelihood of anthropogenic impacts that will exacerbate the natural condition is described below. DEQ staff is proposing to use this approach to implement State Water Control Law 9 VAC 25-260-55, Implementation Procedure for Dissolved Oxygen Criteria in Waters Naturally Low in Dissolved Oxygen.

Before implementing this procedure for low DO or pH, all DO and pH data should be screened for flows less than the 7Q10. DO data collected on days when flow was < 7Q10 should be eliminated from the data set and the violation rate recalculated accordingly.

Step 1. Determine slope and appearance (presence of wetlands).
Step 2. Determine nutrient levels and compare with USGS background concentrations.
Step 3. Determine degree of seasonal fluctuation (for DO only).
Step 4. Determine anthropogenic impacts from permitted dischargers and land use.

At station 2-MOC005.97 on Morris Creek, flow was less than 7Q10 at different periods during 1994, 1995, 1997, 1999, 2001 and 2002. One DO violation was deleted at 2-MOC005.97, which reduced the DO percent violation rate from 50 to 49 percent. At station 2-GUN004.00 on Gunns Run, flow was also less than 7Q10 at different periods during 1994, 1995, 1997, 1999, 2001 and 2002. DO and pH measurements were recorded on two dates during these time periods. The two DO values were above the standard, therefore no change to the percent violations occurred. Two pH violations were deleted at 2-GUN004.00, which reduced the Gunns Run pH percent violation rate from 74 to 73 percent.

On Morris Creek, the hydrologic slope is estimated at 0.20%, which is considered low slope. This low slope contributes no human impact. On Gunns Run, the hydrologic slope is estimated at 0.32%, which is also considered low slope. This low slope contributes no human impact. Decomposition of large inputs of decaying vegetation from areas of forested land with swamps and heavy tree canopy throughout the watershed increase oxygen demand, lower DO, and produce organic acids which lower pH as they decay. These are not considered anthropogenic impacts.

Non-tidal Morris Creek exhibits low nutrient concentrations below national background levels in streams from undeveloped areas, which are not indicative of human impact. Non-tidal Gunns Run exhibits low nutrient concentrations below national background levels in streams from undeveloped areas, with the exception of nitrates determined to come from shallow groundwater inputs to the stream, which become evident during summer low flows. The nitrates do not come from PS or NPS inputs, so are not believed to be due to human impact.

Morris Creek and Gunns Run exhibit natural seasonal DO fluctuation due to the inverse relationship between water temperature and DO.

There is a single permitted VPDES facility located in the Morris Creek watershed, a potable water treatment facility. Mt. Zion/Rustic WTF, permit #VA0085936, is located near Morris Creek approximately 1.5 miles below the monitoring station 2-MOC005.97. All pH values reported by the facility were between the minimum of 6.0 and maximum 9.0, except one high value at pH 9.3. This discharge would not significantly impact pH or DO at the monitoring station. Residential / Commercial land use (0.10%) has no significant effect on pH or DO in the watershed. There is a single Nonmetallic Mineral Mining VPDES General Permit facility, Custom Concrete (VAG840156), with two outfalls to an unnamed tributary to Gunns Run below the DEQ monitoring station 2-GUN004.00. The facility reported pH ranging from 6.2 to 8.7 SU in 2005 and 2006. This discharge would not significantly impact pH or DO at the monitoring station upstream on Gunns Run. Residential / Commercial land use (0.20%) has no significant effect on pH or DO in the watershed.

Based on the above findings, changes in the water quality standards classification to Class VII Swampwater due to natural conditions, rather than a TMDL, are recommended for Morris Creek and its tributaries from its headwaters to the head of tide, and for Gunns Run and its tributaries from its headwaters to the head of tide. If there is a 305(b)/303(d) assessment prior to the reclassification, Morris Creek and Gunns Run will be assessed as Category 4C, Impaired due to natural condition, no TMDL needed.

DEQ performed the assessment of the Morris Creek and Gunns Run low pH and DO natural conditions in lieu of a TMDL. Therefore neither a TMDL Technical Advisory Committee (TAC) meeting nor a public meeting was involved. Public participation will occur during the next water quality standards triennial review process.

1. Introduction

Morris Creek and Gunns Run were listed as impaired on Virginia's 1998 303(d) Total Maximum Daily Load Priority List, the 2002 Impaired Waters Report and 2004 305(b) / 303(d) Integrated Report (VADEQ, 1998, 2002 & 2004) due to violations of the State's water quality standard for dissolved oxygen and pH. This report evaluates the pH and DO impairments by determining if natural conditions are the cause of the impairments, thus obviating the need for a TMDL.

A glossary of terms used throughout this report is presented as Appendix A.

2. Physical Setting

2.1 Listed Water Bodies

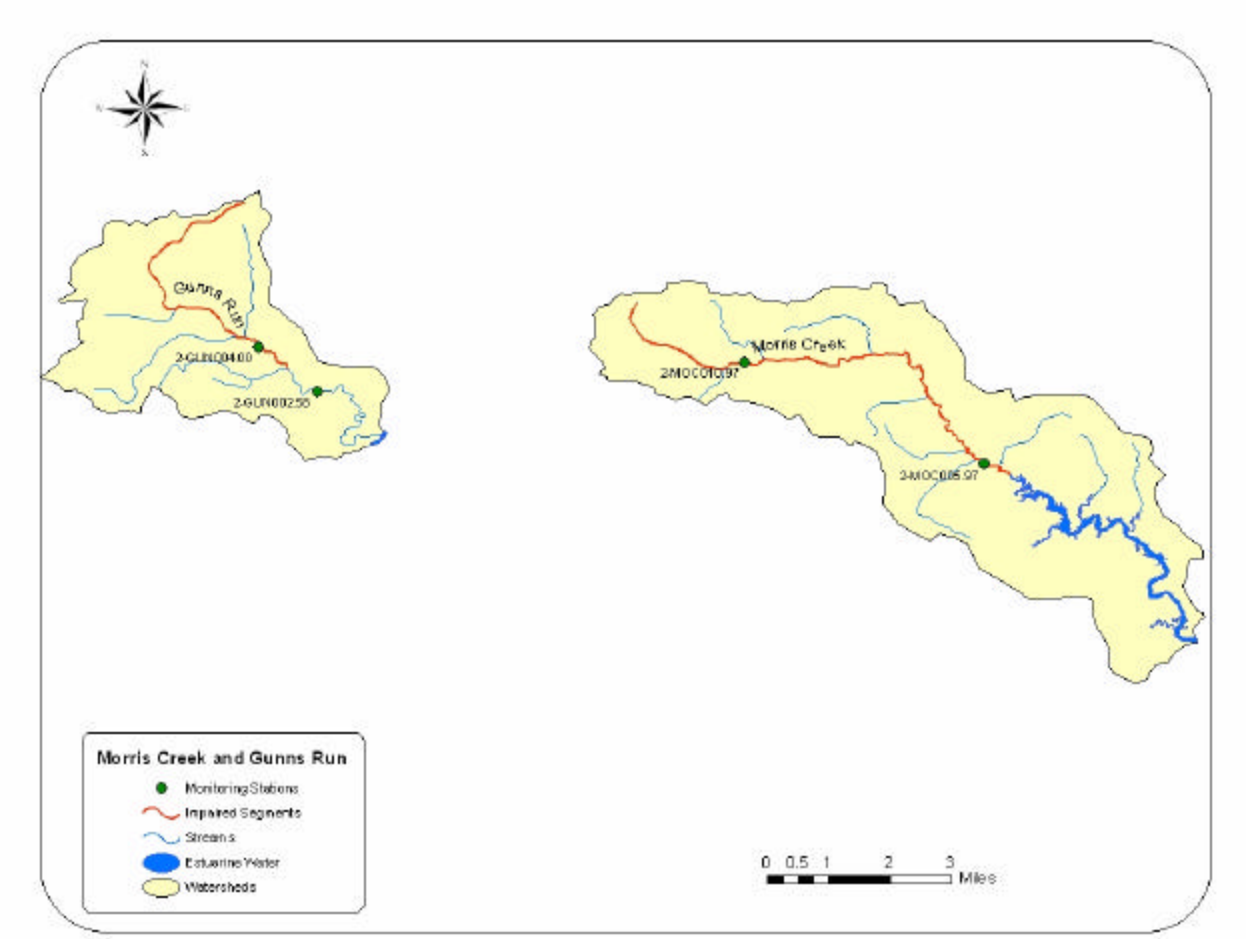
Morris Creek and Gunns Run are located in Charles City County in the James River Basin (USGS Hydrologic Unit Code 02080206). The waterbody identification code (WBID, Virginia Hydrologic Unit) for Morris Creek is VAP-G08R-01, and for Gunns Run is VAP-G03R-01. There are 27.11 stream miles in the Morris Creek watershed and 16.58 stream miles in the Gunns Run watershed (National Hydrography Dataset (NHD). The impaired segments are 7.72 stream miles of Morris Creek and 8.30 stream miles of Gunns Run. These segments are described in Table 1 and Figure 1.

Table 1. Impaired segment descriptions (Morris Creek and Gunns Run).

Segment (segment ID)	Impairment (source of impairment)	Upstream Limit Description	Downstream Limit Description	Miles Affected

Morris Creek, VAP-G08R-01	pH Dissolved Oxygen (Natural conditions)	Headwaters	Tidal limit	7.72
Gunns Run, VAP-G03R-01	pH Dissolved Oxygen (Natural conditions)	Headwaters	Tidal Limit	8.30

Figure 1. Map of the Morris Creek and Gunns Run study areas.



2.2. Watershed

2.2.1. General Description

Morris Creek and Gunns Run, both located within Charles City County, Virginia, are minor tributaries to the Chickahominy River and Queens Creek, respectively. Morris Creek is approximately 13.35 miles long and flows east from its headwaters near Blanks Tavern, VA, between Routes 5 and 615, to its confluence with the Chickahominy River. The watershed has an area of approximately 20 square miles. Gunns Run

is approximately 8.2 miles long and flows southeast from its headwaters near the intersection of Routes 618 and 607 to its confluence with Queens Creek, a tributary of the James River. The watershed has an area of approximately 10 square miles. There is no continuous flow gaging station on Morris Creek or Gunns Run, however there is a gage on the Chickahominy River near Providence Forge, VA (02042500) located 6 miles north of Morris Creek and 5 miles north of Gunns Run, with a drainage area of 252 mi^2.

2.2.2. Geology, Climate, Land Use

Geology and Soils

Morris Creek and Gunns Run are in the Atlantic Coastal Plain physiographic region. The Atlantic Coastal Plain is the easternmost of Virginia's physiographic provinces. The Atlantic Coastal Plain extends from New Jersey to Florida, and includes all of Virginia east of the Fall Line. The Fall Line is the easternmost extent of rocky river rapids, the point at which east-flowing rivers cross from the hard, igneous and metamorphic rocks of the Piedmont to the relatively soft, unconsolidated strata of the Coastal Plain. The Coastal Plain is underlain by layers of Cretaceous and younger clay, sand, and gravel that dip gently eastward. These layers were deposited by rivers carrying sediment from the eroding Appalachian Mountains to the west. As the sea level rose and fell, fossiliferous marine deposits were interlayered with fluvial, estuarine, and beach strata. The youngest deposits of the Coastal Plain are sand, silt and mud presently being deposited in our bays and along our beaches (http://www.runet.edu/~swoodwar/CLASSES/GEOG202/physprov/coastpln.html Radford University).

Soils for the Morris Creek and Gunns Run watersheds were documented utilizing the VA State Soil Geographic Database (STATSGO). Descriptions of these soil series were derived from queries to the USDA Natural Resources Conservation Service (NRCS) Official Soil Series Description web site (http://ortho.ftw.nrcs.usda.gov/cgi-bin/osd/osdlist.cgi). Figure 2 shows the locations of these general soil types in the watersheds.

Morris Creek Watershed Soil Series Descriptions:

Soils of the Emporia-Johnston-Kenansville-Remlik-Slagle-Suffolk-Tomotley-Rumsford Series (VA027) are very deep and range from very poorly to excessively drained conditions. Permeability is slow to moderately rapid. These soils formed out of loamy and sandy sediments, marine sediments and deposits, alluvium, and fluvial sediments along the uplands, sideslopes, floodplains, swamps, and marine terraces of the lower and upper Coastal Plain.

Soils of the Mattoponi-Lenoir-Craven-Coxville Series (VA035) are very deep and range from poorly to well drained conditions. Permeability is slow to moderately slow. These soils formed from fluvial, marine, and clayey sediments and marine deposits along the uplands, flats, depressions, and Carolina bays of the lower to upper Coastal Plain and Piedmont physiographic regions.

Soils of the Pamunkey-Nansemond-Bibb-Kinston-Nawney-Bohicket (VA038) Series are very deep and are poorly to well drained. Permeability is very slow to moderately rapid. These soils formed from loamy—marine and stratified fluvial sediments, stratified loamy and sandy alluvium, loamy, silty, and clayey marine sediment type parent materials. They formed along nearly level to sloping terraces, floodplains, and tidal marshes of the Coastal Plain and Piedmont.

Soils of the Bojac-Pamunkey-Munden-Angie-Augusta-Molena-Argent Series (VA040) are very deep and range from excessively to poorly drained conditions. Permeability is moderately rapid to slow. This series is found along terraces and uplands and is composed of loamy—sandy fluvial and marine Coastal Plain sediments.

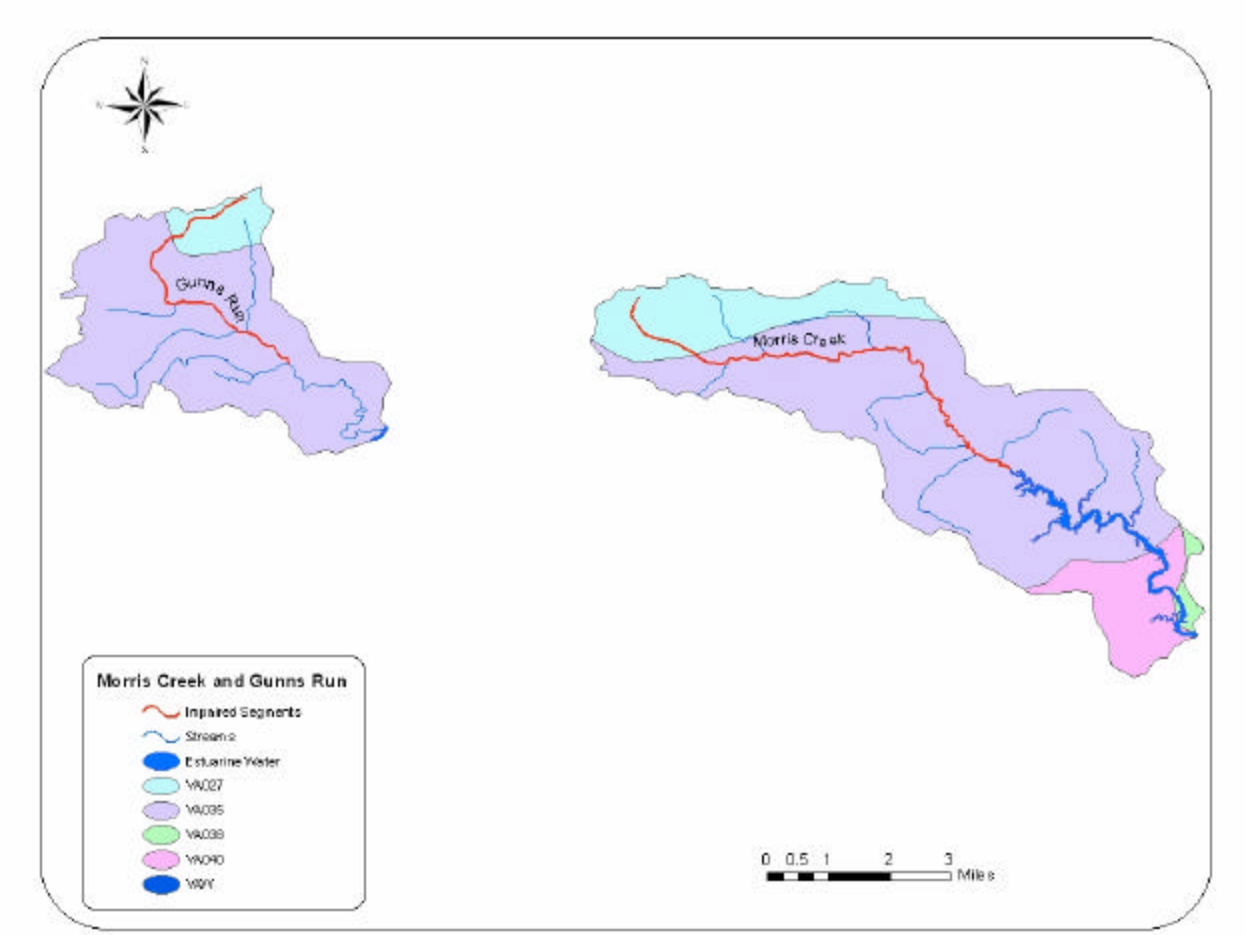
Gunns Run Watershed Soil Series Descriptions:

Soils of the Emporia-Johnston-Kenansville-Remlik-Slagle-Suffolk-Tomotley-Rumsford Series (VA027) are very deep and range from very poorly to excessively drained conditions. Permeability is slow to moderately rapid. These soils formed out of loamy and sandy sediments, marine sediments and

deposits, alluvium, and fluvial sediments along the uplands, sideslopes, floodplains, swamps, and marine terraces of the lower and upper Coastal Plain.

Soils of the Mattoponi-Lenoir-Craven-Coxville Series (VA035) are very deep and range from poorly to well drained conditions. Permeability is slow to moderately slow. These soils formed from fluvial, marine, and clayey sediments and marine deposits along the uplands, flats, depressions, and Carolina bays of the lower to upper Coastal Plain and Piedmont physiographic regions.

Figure 2. Soil Characteristics of Gunns Run and Morris Creek Watersheds



Climate

The climate summary for Morris Creek and Gunns Run comes from a weather station located in Williamsburg, VA with a period of record from 1/21/1972 to 3/31/2004. The average annual maximum and minimum temperature (°F) at the weather station is 69.9 and 47.5 and the annual rainfall (inches) is 47.56 (Table 2) (Southeast Regional Climate Center, http://www.sercc.com/climateinfo/historical/historical_va.html).

Table 2. Climate summary for Williamsburg, Virginia (449151)

Period of Record : 8/ 1/1948 to 12/31/2005

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max. Temperature (F)	48.9	52.1	60.4	71.1	78.2	85.1	88.5	87.0	81.4	71.3	62.5	52.4	69.9
Average Min.	28.0	30.0	36.4	45.3	54.4	62.5	67.4	66.3	60.3	48.5	39.4	31.4	47.5

Temperature (F)													
Average Total Precipitation (in.)	3.71	3.47	4.29	3.21	4.24	3.81	5.43	5.15	4.26	3.35	3.26	3.38	47.56

Land Use

Morris Creek is approximately 13.35 miles long and flows east from its headwaters near Blanks Tavern, VA, between Routes 5 and 615, to its confluence with the Chickahominy River. The watershed is approximately 13,029 acres in size and is predominately forested (72.9 percent). Agriculture encompasses 7.7 percent of the watershed, with 3.6 percent cropland and 4.1 percent pasture/hayland. Residential and high use industrial areas compose approximately 0.1 percent of the land base. The remaining 19.3 percent of the watershed is comprised of 1.7 percent of transitional areas and grasses, and 17.6 percent wetlands and open water. Land use is described in Table 3 and Figure 3 shows a map of the distribution of land use.

Table 3. Land Use in the Morris Creek Watershed

Land Use Category	Land Use Type	Acres	Percent of Watershed's Land Area
Open Water/Wetlands	Open Water	333	2.6
	Wetlands	1957	15
Residential / High Use Industrial (Urban)		10	0.1
Agriculture	Cropland	475	3.6
	Pasture/Hayland	535	4.1
Forest		9501	72.9
Transitional Areas/Grasses		218	1.7
Total		13029	**100**

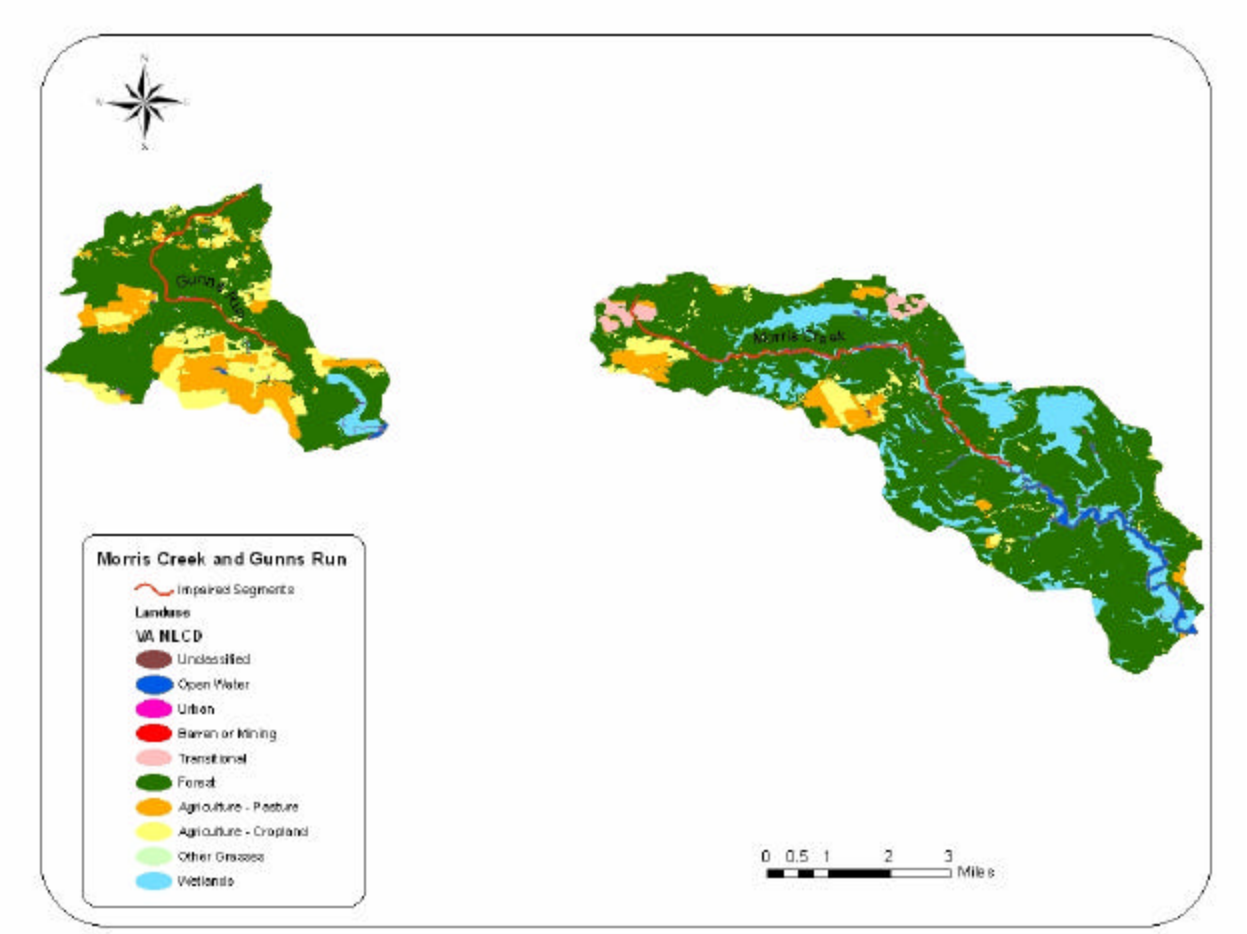
The Gunns Run watershed extends approximately 8.2 miles upstream from its confluence with Queens Creek to its headwaters near the intersection of Rts. 618 and 607, and is about 3 miles wide. The watershed is approximately 6607 acres in size and is predominately forested (64.5 percent). Agriculture encompasses 32.3 percent of the watershed, with 16.3 percent cropland and 16 percent pasture/hayland. Residential and high use industrial areas compose approximately 0.2 percent of the land base. The remaining 3 percent of the watershed is comprised of 3 percent wetlands and open water. Land use is described in Table 4 and Figure 3 shows a map of the distribution of land use.

Table 4. Land Use in the Gunns Run Watershed

Land Use Category	Land Use Type	Acres	Percent of Watershed's Land Area
Open Water/Wetlands	Open Water	42	0.6
	Wetlands	156	2.4
Residential / High Use Industrial (Urban)		11	0.2

Agriculture	Cropland	1076	16.3
	Pasture/Hayland	1058	16
Forest		4264	64.5
Transitional Areas/Grasses		0	0
Total		6607	**100**

Figure 3. Land Use in the Gunns Run and Morris Creek Watersheds



3. Description of Water Quality Problem/Impairment

Morris Creek and Gunns Run were listed as impaired on Virginia's 1998 303(d) Total Maximum Daily Load Priority List, the 2002 Impaired Waters Report and 2004 305(b) / 303(d) Integrated Report (VADEQ, 1998, 2002 & 2004) due to violations of the State's water quality standard for dissolved oxygen and pH.

For Morris Creek, a total of 70 DO data points, with 35 water quality standard violations (50%), have been taken by DEQ at station 2-MOC005.97 from January 17, 1990 through November 15, 2006 (Table 4). A total of 75 pH data points, with 28 water quality standard violations (37%), have been taken by DEQ at station 2-MOC005.97 during this period (Table 5, Figures 4 and 5).

Table 5. DO and pH data collected by DEQ on Morris Creek at Rt. 623.

Station 2-MOC005.97	Date of First Sample	Date of Last Sample	Number of Samples	Average	Minimum	Maximum	Number of Violations
DO, mg/l	1/17/1990	11/15/2006	70	5.11	0.98	11.27	35
pH, S.U.	1/17/1990	11/15/2006	75	6.11	5.01	6.96	28

A time series graph of all DO data collected at station 2-MOC005.97 shows DO concentrations ranging from 0.98 mg/l to 11.27 mg/l (Figure 4). The horizontal line at the DO = 4.0 mg/l mark represents the minimum water quality standard. The data points below the DO = 4.0 mg/l line illustrate violations of the water quality standard. A time series graph of all pH data collected at station 2-MOC005.97 shows pH concentrations ranging from 5.01 S.U. to 6.96 S.U. (Figure 5). The horizontal line at the pH = 6.0 S.U. mark represents the minimum water quality standard. The data points below the pH = 6.0 S.U. line illustrate violations of the water quality standard.

Figure 4. Time series of DO Concentrations at Morris Creek at Rt. 623, 2-MOC005.97.

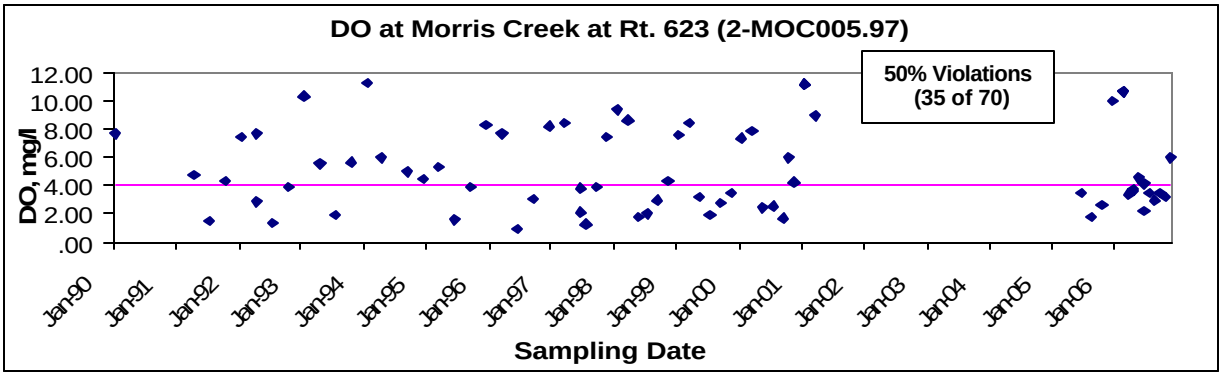
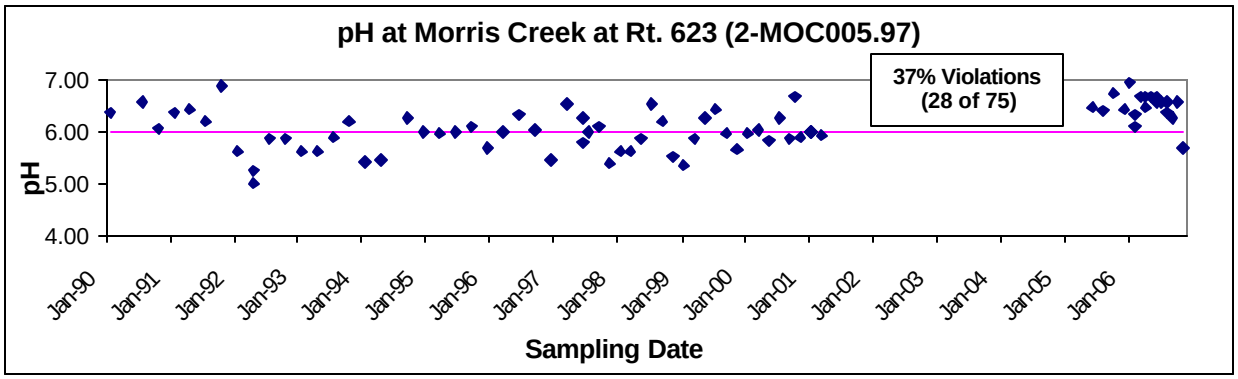


Figure 5. Time series of pH Concentrations at Morris Creek at Rt. 623, 2-MOC005.97



For Gunns Run, a total of 63 DO data points, with 12 water quality standard violations (19%), have been taken by DEQ at station 2-GUN004.00 from January 17, 1990 through April 27, 2005 (Table 5). A total of 66 pH data points, with 49 water quality standard violations (74%), have been taken by DEQ at station 2-GUN004.00 during this period (Table 6, Figures 6 and 7).

Table 6. DO and pH data collected by DEQ on Gunns Run at Rt. 618.

Station 2-GUN004.00	Date of First Sample	Date of Last Sample	Number of Samples	Average	Minimum	Maximum	Number of Violations
DO, mg/l	1/17/1990	4/27/2005	63	6.59	2.32	15.86	12
pH, S.U.	1/17/1990	4/27/2005	66	5.73	4.79	6.92	49

A time series graph of all DO data collected at station 2-GUN004.00 shows DO concentrations ranging from 2.32 mg/l to 15.86 mg/l (Figure 6). The horizontal line at the DO = 4.0 mg/l mark represents the minimum water quality standard. The data points below the DO = 4.0 mg/l line illustrate violations of the water quality standard. A time series graph of all pH data collected at station 2-GUN004.00 shows pH concentrations ranging from 4.79 S.U. to 6.92 S.U. (Figure 7). The horizontal line at the pH = 6.0 S.U. mark represents the minimum water quality standard. The data points below the pH = 6.0 S.U. line illustrate violations of the water quality standard.

Figure 6. Time series of DO Concentrations at Gunns Run at Rt. 618, 2-GUN004.00.

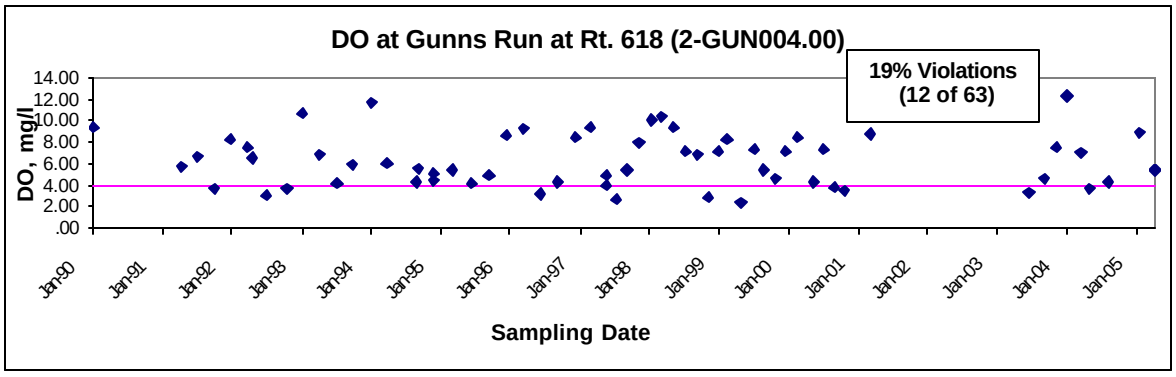
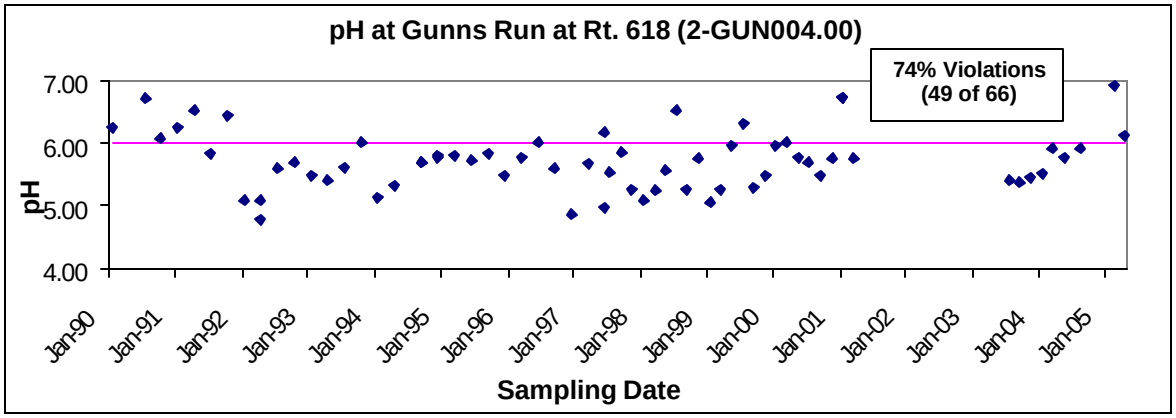


Figure 7. Time series of pH Concentrations at Gunns Run at Rt. 618, 2-GUN004.00.



3.1 Associated Mainstem site DO and pH

DEQ added one associated mainstem monitoring station on Morris Creek during data collection for the low DO and pH assessment of natural conditions or development of a TMDL. Associated station DO and pH data are presented in Figures 8 and 9 below.

Figure 8. DO Concentrations at Morris Creek at Rt. 614, 2-MOC010.97.

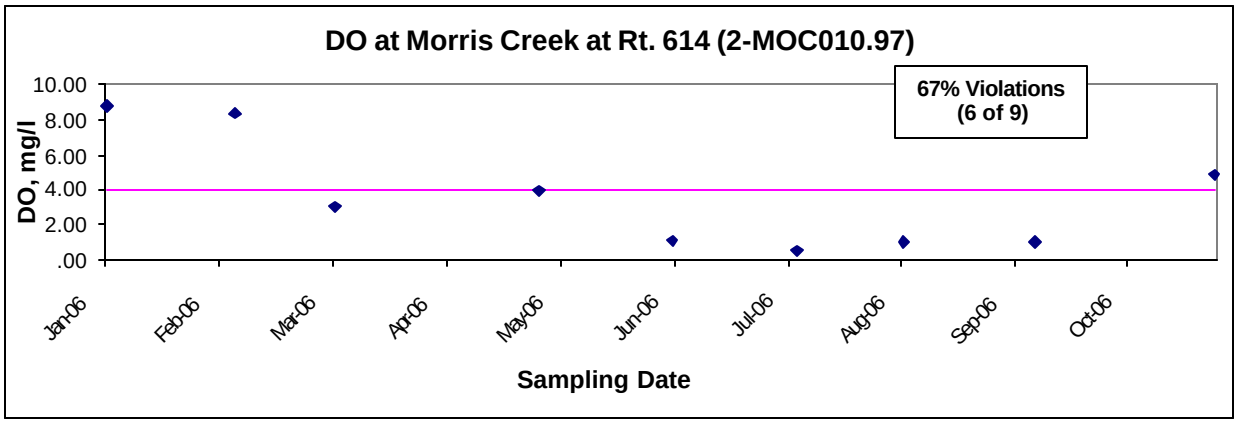
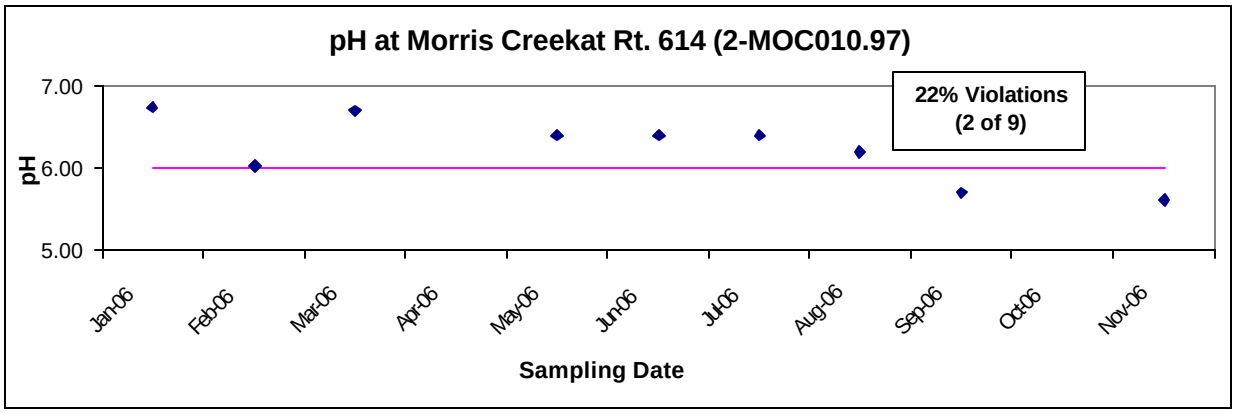


Figure 9. pH Levels at Morris Creek at Rt. 614, 2-MOC010.97.



4. Water Quality Standard

According to Virginia Water Quality Standards (9 VAC 25-260-5), the term *"water quality standards means provisions of state or federal law which consist of a designated use or uses for the waters of the Commonwealth and water quality criteria for such waters based upon such uses. Water quality standards are to protect the public health or welfare, enhance the quality of water and serve the purposes of the State Water Control Law (§62.1-44.2 et seq. of the Code of Virginia) and the federal Clean Water Act (33 USC §1251 et seq.)."*

As stated above, Virginia water quality standards consist of a designated use or uses and a water quality criteria. These two parts of the applicable water quality standard are presented in the sections that follow.

4.1. Designated Uses

According to Virginia Water Quality Standards (9 VAC 25-260-10A), *"all state waters are designated for the following uses: recreational uses (e.g., swimming and boating); the propagation and growth of a balanced indigenous population of aquatic life, including game fish, which might be reasonably expected to inhabit them; wildlife; and the production of edible and marketable natural resources (e.g., fish and shellfish)."*

As stated above, Morris Creek and Gunns Run must support all designated uses and meet all applicable criteria.

4.2. Applicable Water Quality Criteria

The applicable water quality criteria for DO and pH in the Morris Creek and Gunns Run watersheds are an instantaneous minimum DO of 4.0 mg/l, and a range of pH from 6.0 S.U. to 9.0 S.U. (Table 7).

Table 7. Applicable water quality standards

Parameter	Minimum, mg/l	Maximum, mg/l
DO	4.0	NA
pH	6.0	9.0

If the waterbody exceeds the criteria listed above in more than 10.5 percent of samples, the waterbody is classified as impaired and natural conditions must be determined or a TMDL must be developed and implemented to bring the waterbody into compliance with the water quality criterion.

5. Assessment of Natural Conditions Affecting low DO - Process for determining if DO and pH impairments in free-flowing streams are due to natural conditions.

The level of dissolved oxygen in a water body is determined by a balance between oxygen-depleting processes (*e.g.*, decomposition and respiration) and oxygen-restoring processes (*e.g.*, aeration and photosynthesis). Certain natural conditions promote a situation where oxygen-restoring processes are not sufficient to overcome the oxygen- depleting processes. The level of pH in a water body is determined by a balance between organic acids produced by decay of vegetative material, and buffering capacity. Conditions in a stream that would typically be associated with naturally low DO and pH include slow-moving, ripple-less waters or wetlands where the decay of organic matter produces organic acids. These situations can be compounded by anthropogenic activities that contribute excessive nutrients or readily available organic matter to these systems. The general approach to determine if DO and pH impairments in streams are due to natural conditions is to assess a series of water quality and hydrologic criteria to determine the likelihood of an anthropogenic source.

A logical 4-step process for identifying natural conditions that result in low DO and/or pH levels and for determining the likelihood of anthropogenic impacts that will exacerbate the natural condition is described below.

Step 1. Determine slope and appearance.
Step 2. Determine nutrient levels.
Step 3. Determine degree of seasonal fluctuation (for DO only).
Step 4. Determine anthropogenic impacts.

The results from this methodology (or process or approach) will be used to determine if the stream should be re-classified as Class VII Swamp Waters. Each step is described in detail below.

Procedure for Natural Condition Assessment of low pH and low DO in Virginia Streams

Prepared by Virginia Department of Environmental Quality
October 2004

I. INTRODUCTION

Virginia's list of impaired waters currently shows many waters as not supporting the aquatic life use due to exceedances of pH and/or DO criteria that are designed to protect aquatic life in Class III waters. However, there is reason to believe that most of these streams or stream segments have been mis-classified and should more appropriately be classified as Class VII, Swamp Waters. This document presents a procedure for assessing if natural conditions are the cause of the low pH and/or low DO levels in a given stream or stream segment.

The level of dissolved oxygen (DO) in a water body is determined by a balance between oxygen-depleting processes (*e.g.*, decomposition and respiration) and oxygen-restoring processes (*e.g.*, aeration and photosynthesis). Certain natural conditions promote a situation where oxygen-restoring processes are not sufficient to overcome the oxygen-depleting processes. The level of acidity as registered by pH in a water body is determined by a balance between organic acids produced by decay of vegetative material, and buffering capacity.

Conditions in a stream that would typically be associated with naturally low DO and/or naturally low pH include slow-moving, ripple-less waters. In such waters, the decay of organic matter depletes DO at a faster rate than it can be replenished and produces organic acids (tannins, humic and fulvic substances). These situations can be

compounded by anthropogenic activities that contribute excessive nutrients or readily available organic matter to these systems.

The general approach to determine if DO and pH impairments in streams are due to natural conditions is to assess a series of water quality and hydrologic criteria to determine the likelihood of an anthropogenic source. A logical 4-step process for identifying natural conditions that result in low DO and/or pH levels and for determining the likelihood of anthropogenic impacts that will exacerbate the natural condition is described below. DEQ staff is proposing to use this approach to implement State Water Control Law 9 VAC 25-260-55, Implementation Procedure for Dissolved Oxygen Criteria in Waters Naturally Low in Dissolved Oxygen.

Waters that are shown to have naturally low DO and pH levels will be re-classified as Class VII, Swamp Waters, with the associated pH criterion of 4.3 to 9.0 SU. An associated DO criterion is currently being developed from swamp water data. A TMDL is not needed for these waters. An assessment category of 4C will be assigned until the waterbody has been re-classified.

II. NATURAL CONDITION ASSESSMENT

Following a description of the watershed (including geology, soils, climate, and land use), a description of the DO and/or pH water quality problem (including a data summary, time series and monthly data distributions), and a description of the water quality criteria that were the basis for the impairment determination, the available information should be evaluated in four steps.

Step 1. Determine appearance and flow/slope.

Streams or stream segments that have naturally low DO (< 4 mg/L) and low pH (< 6 SU) are characterized by very low slopes and low velocity flows (flat water with low reaeration rates). Decaying vegetation in such swampy waters provides large inputs of plant material that consumes oxygen as it decays. The decaying vegetation in a swamp water also produces acids and decreases pH. Plant materials contain polyphenols such as tannin and lignin. Polyphenols and partially degraded polyphenols build up in the form of tannic acids, humic acids, and fulvic acids that are highly colored. The trees of swamps have higher polyphenolic content than the soft-stemmed vegetation of marshes. Swamp streams (blackwater) are therefore more highly colored and more acidic than marsh streams.

Appearance and flow velocity (or slope if flow velocity is not available) must be identified for each stream or stream segment to be assessed for natural conditions and potential re-classification as a Class VII swamp water. This can be done through maps, photos, field measurements or other appropriate means.

Step 2. Determine nutrient levels.

Excessive nutrients can cause a decrease in DO in relatively slow moving systems, where aeration is low. High nutrient levels are an indication of anthropogenic inputs of

nitrogen, phosphorus, and possibly organic matter. Nutrient input can stimulate plant growth, and the resulting die-off and decay of excessive plankton or macrophytes can decrease DO levels.

USGS (1999) estimated national background nutrient concentrations in streams and groundwater from undeveloped areas. Average nitrate background concentrations are less than 0.6 mg/L for streams, average total nitrogen (TN) background concentrations are less than 1.0 mg/L, and average background concentrations of total phosphorus (TP) are less than 0.1 mg/L.

Nutrient levels must be documented for each stream or stream segment to be assessed for natural conditions and potential re-classification as a Class VII swamp water. Streams with average concentrations of nutrients greater than the national background concentrations should be further evaluated for potential impacts from anthropogenic sources.

Step 3. Determine degree of seasonal fluctuation (for DO only).

Anthropogenic impacts on DO will likely disrupt the typical seasonal fluctuation seen in the DO concentrations of wetland streams. Seasonal analyses should be conducted for each potential Class VII stream or stream segment to verify that DO is depressed in the summer months and recovers during the winter, as would be expected in natural systems. A weak seasonal pattern could indicate that human inputs from point or nonpoint sources are impacting the seasonal cycle.

Step 4. Determine anthropogenic impacts.

Every effort should be made to identify human impacts that could exacerbate the naturally low DO and/or pH. For example, point sources should be identified and DMR data analyzed to determine if there is any impact on the stream DO or pH concentrations. Land use analysis can also be a valuable tool for identifying potential human impacts.

Lastly, a discussion of acid rain impacts should be included for low pH waters. The format of this discussion can be based either on the process used for the recent Class VII classification of several streams in the Blackwater watershed of the Chowan Basin (letter from DEQ to EPA, 14 October 2003). An alternative is a prototype regional stream comparison developed for Fourmile Creek, White Oak Swamp, Matadequin Creek and Mechumps Creek (all east of the fall line). The example analysis under IV in this document, or the example report prepared for Fourmile Creek, illustrate this approach. For streams west of the fall line, a regional stream comparison for 2004 analyses encompasses Winticomack, Winterpock, and Butterwood Creeks.

7Q10 Data Screen

If the data warrant it, a data screen should be performed to ensure that the impairment was identified based on valid data. All DO or pH data that violate water quality

standards should be screened for flows less than the 7Q10. Data collected on days when flow was < 7Q10 should be eliminated from the data set and the violation rate recalculated accordingly. Only those waters with violation rates determined days with flows > or = 7Q10 flows should be classified as impaired.

In some cases, data were collected when flow was 0 cfs. If the 7Q10 is identified as 0 cfs as well, all data collected under 0 cfs flow would need to be considered in the water quality assessment. In those cases, the impairment should be classified as 4C, Impaired due to natural conditions, no TMDL needed. However, a reclassification to Class VII may not always be appropriate.

III. NATURAL CONDITION CONCLUSION MATRIX

The following decision process should be applied for determining whether low pH and/or low DO values are due to natural conditions and justify a reclassification of a stream or stream segment as Class VII, Swamp Water.

If velocity is low or if slope is low (<0.50%) AND
If wetlands are present along stream reach AND
If no point sources or only point sources with minimal impact on DO and pH AND
If nutrients are < typical background

- ❖ average (= assessment period mean) nitrate less than 0.6 mg/L
- ❖ average total nitrogen (TN) less than 1.0 mg/L, and
- ❖ average total phosphorus (TP) are less than 0.1 mg/L AND

For DO: If seasonal fluctuation is normal AND
For pH: If nearby streams without wetlands meet pH criteria OR if no correlation between in-stream pH and rain pH,

THEN determine as impaired due to natural condition
→ assess as category 4C in next assessment
→ initiate WQS reclassification to Class VII Swamp Water
→ get credit under consent decree

The analysis must state the extent of the natural condition based on the criteria outlined above. A map showing land use, point sources, water quality stations and, if necessary, the delineated segment to be classified as swamp water should be included.

In cases where not all of these criteria apply, a case by case argument must be made based on the specific conditions in the watershed.

5.1 Preliminary Data Screen for Low Flow 7Q10

The 7Q10 flow of a stream is the lowest streamflow for seven consecutive days that occurs on average once every ten years. The first step for low flow 7Q10 screening is to determine the most accurate 7Q10 available. There is no long-term flow gaging station in the Morris Creek or Gunns Run watersheds.

The 7Q10 flows for the Morris Creek and Gunns Run stations may be estimated by a drainage area comparison between Morris Creek and Gunns Run stations and the drainage area and 7Q10 flow at the Chickahominy River near Providence Forge, VA gauging station 02042500, located 6 miles north of Morris Creek and 5 miles north of Gunns Run, with a drainage area of 252 mi^2. The 7Q10 for the

Chickahominy River gauge was 1.3 cfs. The 7Q10 flow for Gunns Run with a drainage area of 10.3 mi^2 is 0.05 cfs. The 7Q10 flow for Morris Creek with a drainage area of 20.4 mi^2 is 0.11 cfs.

The DO Instantaneous Water Quality Standard applies **AT** 7Q10 flow, but **NOT** below 7Q10 flow (9 VAC 25-260-50 ***). Therefore in streams where the 7Q10 > 0.0 cfs, DO less than 4.0 mg/l taken at flows below 7Q10 are not water quality standard violations. However, in streams where the 7Q10 = 0.0 cfs, **ALL** DO data < 4.0 mg/l are standard violations, even if the flow = 0 cfs when the DO was taken.

At station 2-MOC005.97 on Morris Creek, flow was less than 7Q10 at different periods during 1994, 1995, 1997, 1999, 2001 and 2002. DO and pH measurements were recorded on one date during these time periods. One DO violation was deleted at 2-MOC005.97, which reduced the DO percent violation rate from 50 to 49 percent. The Morris Creek pH below 7Q10 was above the standard. At station 2-GUN004.00 on Gunns Run, flow was also less than 7Q10 at different periods during 1994, 1995, 1997, 1999, 2001 and 2002. DO and pH measurements were recorded on two dates during these time periods. The two DO values were above the standard, therefore no change to the percent violations occurred. Two pH violations were deleted at 2-GUN004.00. These reduced the Gunns Run pH percent violation rate from 74 to 73 percent.

5.2 Low slope, Swamps, Wetlands or Large Forested Areas

There were no discharge measurements made during the study period at the Rt. 623 bridge, 2-MOC005.97, or Rt. 618 at 2-GUN004.00, the original 303(d) listing stations. On Morris Creek, the hydrologic slope from the 70 ft. topographic contour at rivermile 13.35, located at the mainstem headwater, downstream to the 5 ft topographic contour at rivermile 7.32, located 1.35 miles above Rt. 623, is estimated at 0.20%, which is considered low slope. The low slope in this 6.03 mile segment contributes no human impact. Decomposition of large inputs of decaying vegetation from areas of forested land with swamps and heavy tree canopy throughout the watershed increase oxygen demand, lower DO, and produce organic acids which lower pH as they decay. These are not considered anthropogenic impacts.

On Gunns Run, the hydrologic slope from the 90 ft. topographic contour at rivermile 7.85, located 0.1 mi below Rt. 641, downstream to the 10 ft topographic contour at rivermile 3.06, located 0.46 miles above Rt. 5, is estimated at 0.32%, which is considered low slope. The low slope in this 4.79 mile segment contributes no human impact. Decomposition of large inputs of decaying vegetation from areas of forested land with swamps and heavy tree canopy throughout the watershed increase oxygen demand, lower DO, and produce organic acids which lower pH as they decay. These are not considered anthropogenic impacts.

Visual inspections from sampling points along Morris Creek and Gunns Run revealed swampy and large forested areas. Decomposition of the large inputs of decaying vegetation from swampy and heavily forested areas in this part of the watershed increase oxygen demand, lower DO, and produce organic acids which lower pH as they decay. (See Figures 10-16).

Figure 10. Morris Creek at rivermile 6.67, 0.7 miles above Rt. 623

Figure 11. Morris Creek at rivermile 10.97, looking upstream from Rt. 614.

Figure 12. Gunns Run at river mile 4.34, 0.3 miles above Rt. 618.

Figure 13. Gunns Run at river mile 4.53, 0.5 miles above Rt. 618.

Figure 15. Gunns Run at river mile 5.77, 0.8 miles south of Rt. 607.

Figure 15. UT to Gunns Run (XZY), at river mile 0.58.

Figure 16. UT to Gunns Run (XZY), at river mile 1.88.

5.3 Instream Nutrients

The VADEQ collected nutrient data from stations 2-MOC005.97 from July 1990 to May 2007 and 2-GUN004.00 from July 1990 to Mar 2001 (Table 8 - 9).

Table 8. Instream Nutrients of Morris Creek at Rt. 623, 2-MOC005.97.

Parameter	Average Conc.	Number
Total Phosphorus	**0.116 mg/l** *	(n=63)
Orthophosphorus	0.073 mg/l	(n=50)
Total Kjeldahl Nitrogen	0.873 mg/l	(n=50)
Ammonia as N	0.039 mg/l	(n=63)
Nitrate as N	**0.035 mg/l**	(n=50)
Nitrite as N	0.011 mg/l	(n=50)
TN (TKN + NO_3 + NO_2)	**0.919 mg/l**	(n=50)

Table 9. Instream Nutrients of Gunns Run at Rt. 618, 2-GUN004.00.

Parameter	Average Conc.	Number
Total Phosphorus	**0.046 mg/l**	(n=59)
Orthophosphorus	0.022 mg/l	(n=49)
Total Kjeldahl Nitrogen	0.746 mg/l	(n=50)
Ammonia as N	0.049 mg/l	(n=59)
Nitrate as N	**3.446mg/l** *	(n=50)
Nitrite as N	0.015 mg/l	(n=50)
TN (TKN + NO_3 + NO_2)	**4.207 mg/l** *	(n=50)

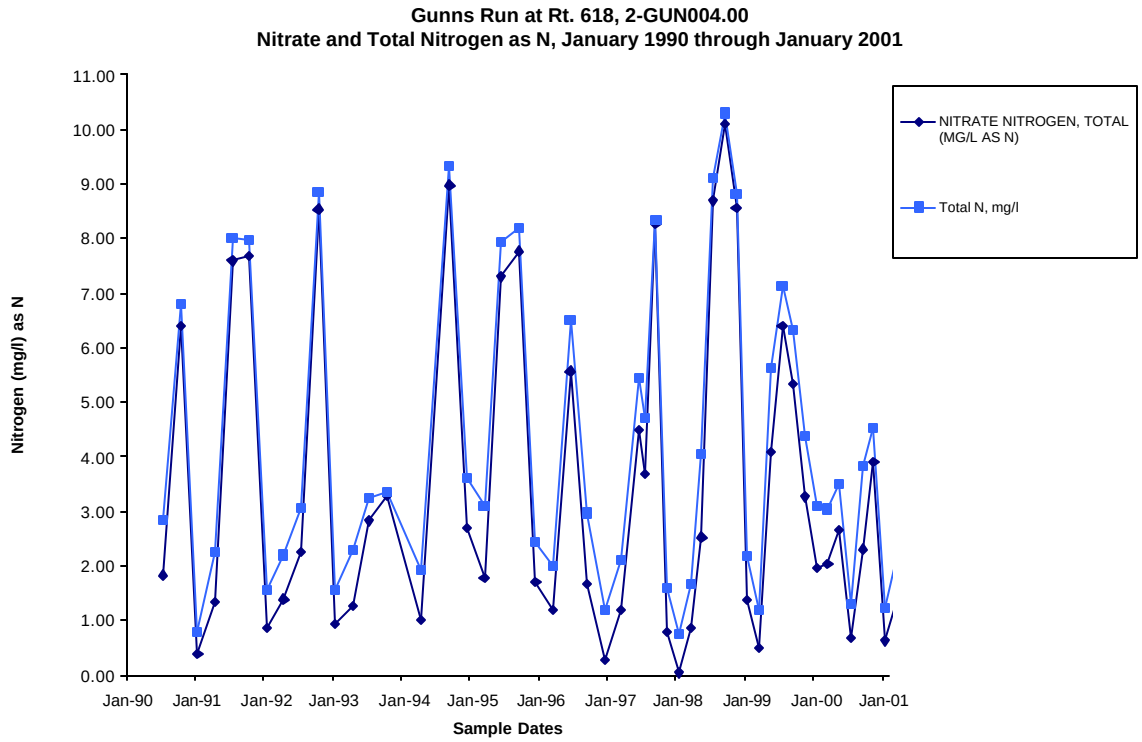
* - see explanation below

These average nutrient concentrations are at or below the USGS (1999) national background nutrient concentrations in streams from undeveloped areas (nitrate < 0.6 mg/l; TN (TKN + NO_3 + NO_2) < 1.0 mg/l; and TP < 0.1 mg/l), except for TP in Morris Creek and nitrate, including resultant TN, in Gunns Run. These USGS nutrient levels serve as a guideline to indicate non-anthropogenic nutrient inputs.

Morris Creek station 2-MOC005.97 is located **AT** the head of tide, and twice per day on high tides it receives flushes of upper estuary tidal fresh water high in vegetative decay products which often contains TP above 0.1 mg/l. To check TP levels in non-tidal Morris Creek, DEQ sampled TP from March to July 2008 at the Rt. 614 bridge, station 2-MOC010.97, located 5.0 miles above the head of tide. Average TP at the non-tidal station was 0.09 mg/l (n=6), under the USGS (1999) background concentration. These nutrient levels are not considered indicative of human impact.

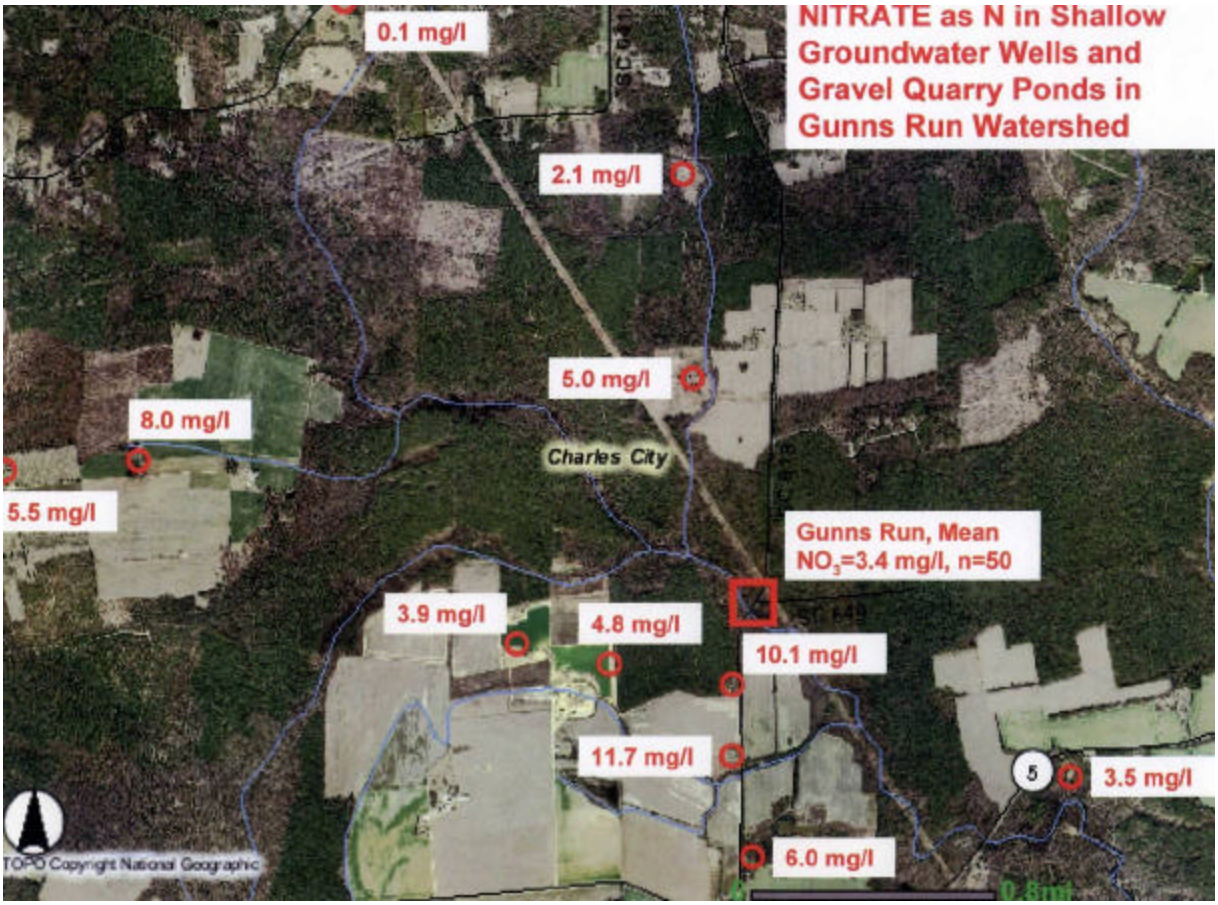
Nitrate at Gunns Run station 2-GUN004.00 was elevated. Historical nitrate levels at 2-GUN004.00 are shown in Figure 17, which shows that nitrate and resultant total nitrogen levels elevate in summer and return to normal in winter.

Figure 17. Historical Nitrates and Total Nitrogen at Gunns Run, 1990 – 2001.



To determine the reason for this nitrate anomaly, DEQ performed a study of nitrates in surface waters and shallow groundwater in the Gunns Run watershed from March – July 2008. The results of this study are shown in Figure 18.

Figure 18. Nitrate as N in Shallow Groundwater Wells and Gravel Quarry Ponds in the Gunns Run Watershed, March – April 2008.



There is a gravel quarry with two large ponds in the Gunns Run watershed within one mile of the Gunns Run station. Gravel is taken from one pond with process water for washing the product, and the process water is returned to the other pond. DEQ determined by inspection that these ponds do not receive surface water inflow from any stream, nor does surface water drain from them to Gunns Run above the original listing station. There is an occasional permitted process water discharge from the western-most pond to an unnamed tributary just to the south of the ponds, which drains to Gunns Run approximately 0.8 miles below Rt. 618. The nitrate levels in the two ponds were 4.8 mg/l and 3.9 mg/l respectively in two samples apiece in March and April 2008. DEQ believes these nitrate levels are from shallow groundwater influx into the ponds. To gain more knowledge about groundwater nitrate in the watershed, DEQ then sampled nine (9) shallow groundwater wells (well depth 20 – 40 ft.) in the Gunns Run watershed. These wells had an average nitrate concentration of 5.8 mg/l. The minimum nitrate concentration was 0.1 mg/l in the background well in the far northern portion of the watershed at highest elevation, and the maximum nitrate levels of 10.1 mg/l and 11.7 mg/l NO_3 were located in two shallow drinking water wells within 0.8 miles south of station 2-GUN004.00. DEQ believes that the nitrate results from these wells and quarry ponds indicate that nitrate is present in elevated levels in the shallow groundwater in the middle and southern portions of this watershed where elevations are low.

DEQ next had to determine if the high nitrate levels in Gunns Run may be caused by recent agricultural land use in this area. There is a large expanse of agricultural fields to the west, south and east of the gravel quarry as can be seen in Figure 19. These fields are part of Evelynton Farm. This land may have been in agricultural use for hundreds of years, because this general area is part of the early colonial expansion in Virginia. DEQ sampled the unnamed tributary (Station Code XZY) to the north side of these fields at stations upstream and downstream of the complex of fields to see if surface runoff from the fields, which do receive biosolids applications annually, could be causing elevated nitrates in Gunns Run. These results are shown in Table 10. These results show that there has been no detectable nitrate (detection limit 0.04 mg/l as N) in the tributary bracketing the agricultural fields on Evelynton Farm since March 2008. Biosolids were applied to the Evelynton fields before the March 31 sample event, and no nitrate was detected downstream in the unnamed tributary after the application. The April 21 sample was

taken during a flood to check whether high flows contributed a major load of nitrates, and this result was also below detection. Therefore DEQ does not believe that the nitrates in Gunns Runn come from surface runoff from the Evelynton Farm fields, or from excessive stormwater runoff. In June and July 2008, nitrates increased in Gunns Run as streamflows decreased and the XZY tributary below Evelynton Farm was not flowing and almost dry. This appears similar to the summer increase of nitrates shown in the historical data for Gunns Run (see Figure 18).

DEQ believes the nitrate levels in Gunns Run are caused by shallow groundwater inputs to the stream which are diluted in higher seasonal flows, but comprise a greater percentage and higher concentration in summer low flows in Gunns Run in the absence of surface runoff. DEQ does not believe it is logistically practicable to remove the nitrates from the shallow groundwater aquifer in the watershed.

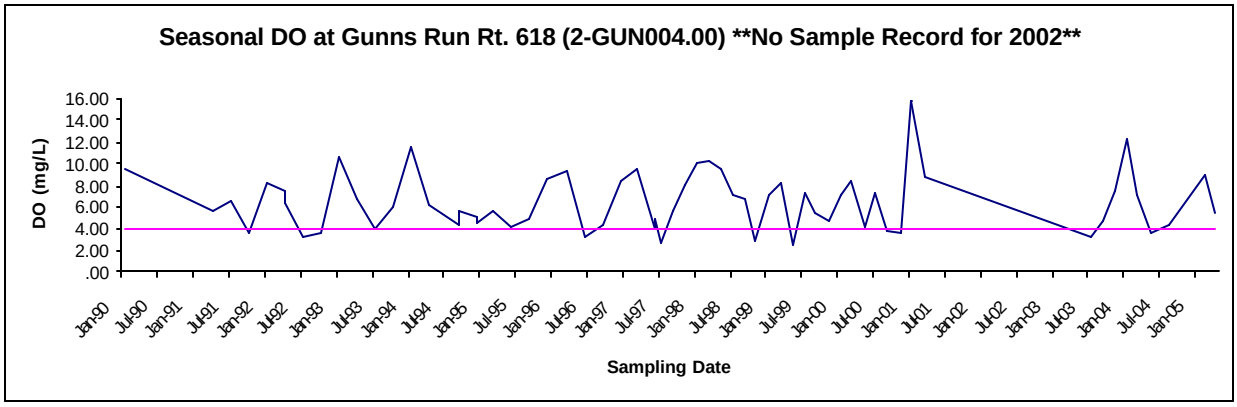
Table 10. Nitrates in an Unnamed Tributary of Gunns Run (XZY) Bracketing Evelynton Farm Fields, March – July 2008.

Date	2-XZY001.88, upstream of Evelynton Farm	2-XZY000.39, downstream of Evelynton Farm	2-GUN004.00, at Rt. 618, below tributary XZY	Notes
3/5/2008	<0.04		0.18	Normal Flow, no biosolids yet
3/31/2008	<0.04	<0.04	0.21	Normal flow, **biosolids applied at Evelynton Farm since last visit**
4/17/2008	<0.04	<0.04	0.19	Normal Flow
4/21/2008			<0.04	In Flood
5/1/2008	No Flow	<0.04	0.04	Normal Flow
5/21/2008	No Flow	<0.04	0.16	Normal Flow
6/4/2008	No Flow	<0.04	0.20	Normal Flow
6/17/2008	No Flow	No Flow	1.43	Low Flow
7/1/2008	No Flow	No Flow	1.69	Low Flow

5.4 Natural Seasonal DO Fluctuation

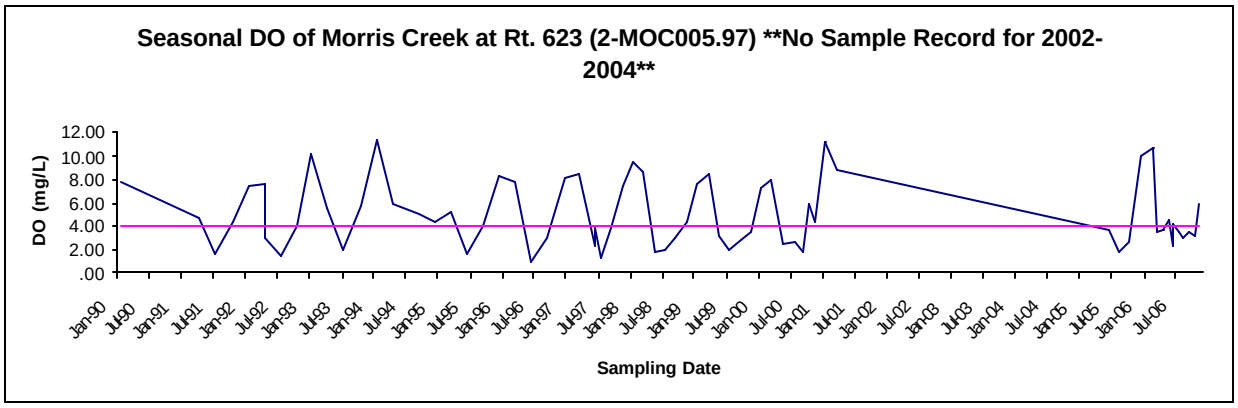
Gunns Run exhibits natural seasonal DO fluctuation due to the inverse relationship between water temperature and DO. DO is high in the winter months while water temperatures are low, and low in the summer months when water temperatures are high. This is depicted in Figure 19.

Figure 19. Seasonal Variation in DO of Gunns Run at Rt. 618, 2000– 2005.



Morris Creek exhibits natural seasonal DO fluctuation due to the inverse relationship between water temperature and DO. DO is high in the winter months while water temperatures are low, and low in the summer months when water temperatures are high. This is depicted in Figure 20.

Figure 20. Seasonal Variation in DO of Morris Creek at Rt. 623, 2000– 2006.



5.5 Impact from Point Source Dischargers and Land Use

Morris Creek

There is one VPDES permitted facility in the Morris watershed, Mt. Zion/Rustic Water Treatment Facility (WTF) (#VA0085936). This drinking water production facility has an outfall to a marsh approximately 25 ft from tidal Morris Creek approximately 1.5 miles below the DEQ monitoring station 2-MOC005.97. Quarterly samples submitted by the WTF showed one documented high pH violation out of 20 total samples (sampling period from 8/1/02 to 11/30/07). The report indicated a pH value of 9.3 (permitted maximum of 9.0) on 1/13/05. All other values indicate pH values between the minimum of 6.0 and maximum 9.0. This discharge would not significantly impact pH or DO at the monitoring station.

There is also one Storm Water Construction Permit (#VAR440793) which drains to Morris Creek. The permit was issued on July 1, 2004 and will expire on June 30, 2009. There was no monitoring data required for the permit and the short-term disturbed land use is not considered to have a significant impact on pH or DO.

Residential and high use industrial areas compose approximately 0.1 percent of the land base, an insignificant portion of the watershed. The watershed is predominately forested (72.9 percent), with 17.6 percent wetlands and open water. This land use was not considered as indicative of human impact.

Agriculture contributes 7.7 percent of land use however there were no biosolids permits on file for the Morris Creek watershed.

Gunns Run

There is one Nonmetallic Mineral Mining VPDES General Permit facility named “Custom Concrete” with two outfalls to an unnamed tributary to Gunns Run (#VAG840156) below the DEQ monitoring station 2-GUN004.00. Outfall 001 carries storm water and 002 is an outfall of process-water co-mingled with storm water. This tributary join Gunns Run below the impaired station 2-GUN004.00 and thus does not affect pH at the original impaired station. Custom Concrete submits quarterly monitoring samples of TSS, pH, and flow for both outfalls. The facility reported pH ranging from 6.2 to 8.7 SU and TSS from 2.5 mg/l to

88 mg/l in 2005 and 2006. This discharge would not significantly impact pH or DO at the monitoring station upstream on Gunns Run.

Residential and high use industrial areas compose approximately 0.2 percent of the land base, an insignificant portion of the watershed. The watershed is predominately forested (64.5 percent), with 3.0 percent wetlands and open water. This land use was not considered as indicative of human impact.

Agricultural land use comprises 32.3 percent of the watershed. There are two biosolids permits on file that are within the Gunns Run watershed. Haupt Farm was permitted in 1989 and 1994. Biosolids were applied to 31.5 acres in 1989 and 232.5 acres in 1994. Evelynton Farms was permitted for biosolids beginning in 1996 and applies biosolids to approximately 140 acres each year. This occurred in March of 2008.

6.0 CONCLUSION

The following decision process is proposed for determining whether low DO values are due to natural conditions:

If slope is low (<0.50) AND
If wetlands or large areas of forested land are present along stream reach AND
If no point sources or point sources with minimal impact on DO AND
If nutrients are < typical background guideline

- ❖ average (= assessment period mean) nitrate less than 0.6 mg/L
- ❖ average total nitrogen (TN) less than 1.0 mg/L, and
- ❖ average total phosphorus (TP) are equal to or less than 0.1 mg/L AND

If nearby streams without wetlands meet DO criteria,

THEN determine as impaired due to natural condition
→ assess as category 4C in next assessment
→ initiate WQS reclassification to Class VII Swamp Water
→ get credit under consent decree

The hydrologic slope of Morris Creek is estimated at 0.20%, which is considered low slope. The low slope is from its headwaters to the head of tide near river mile 5.97. Decomposition of the large inputs of decaying vegetation from areas of forested land with swamps and heavy tree canopy throughout the watershed increase oxygen demand and lower DO as they decay. These are not considered anthropogenic impacts.

Morris Creek exhibits low nutrient concentrations below national background levels in streams from undeveloped areas, which are not indicative of human impact.

Morris Creek exhibits natural seasonal DO fluctuation due to the inverse relationship between water temperature and DO.

There is a single permitted VPDES facility located in the Morris Creek watershed, a potable water treatment facility. Mt. Zion/Rustic WTF, permit #VA0085936, is located near Morris Creek approximately 1.5 miles below the monitoring station 2-MOC005.97. All pH values reported by the facility were between the minimum of 6.0 and maximum 9.0, except one high value at pH 9.3. This discharge would not significantly impact pH or DO at the monitoring station. Residential / Commercial land use (0.10%) has no significant effect on pH or DO in the watershed.

Based on the above findings, a change in the water quality standards classification to Class VII Swampwater due to natural conditions, rather than a TMDL, is recommended for Morris Creek and its tributaries from its headwaters downstream to the head of tide at rivermile 5.97. If there is a 305(b)/303(d) assessment prior to the reclassification, Morris Creek will be assessed as Category 4C, Impaired due to natural condition, no TMDL needed.

The hydrologic slope of Gunns Run is estimated at 0.32%, which is considered low slope. The low slope is from its headwaters to the head of tide at rivermile 2.64 just above Rt. 5. Decomposition of the large inputs of decaying vegetation from areas of forested land with swamps and heavy tree canopy throughout the watershed increase oxygen demand and lower DO as they decay. These are not considered anthropogenic impacts.

Gunns Run exhibits low nutrient concentrations below national background levels in streams from undeveloped areas, with the exception of nitrates determined to come from shallow groundwater inputs to the stream, which become evident during summer low flows. The nitrates do not come from PS or NPS inputs, so are not believed to be due to human impact.

Gunns Run exhibits natural seasonal DO fluctuation due to the inverse relationship between water temperature and DO.

There is one Nonmetallic Mineral Mining VPDES General Permit facility, Custom Concrete (VAG840156) with two outfalls to an unnamed tributary of Gunns Run below the DEQ monitoring station 2-GUN004.00. Outfall 001 carries storm water and 002 is an outfall of process-water co-mingled with storm water. The facility reported pH ranging from 6.2 to 8.7 SU and TSS from 2.5 mg/l to 88 mg/l in 2005 and 2006. This discharge would not significantly impact pH or DO at the monitoring station upstream on Gunns Run. Residential / Commercial land use (0.20%) has no significant effect on pH or DO in the watershed.

Based on the above findings, a change in the water quality standards classification to Class VII Swampwater due to natural conditions, rather than a TMDL, is indicated for Gunns Run and its tributaries from its headwaters downstream to the head of tide at rivermile 2.64. If there is a 305(b)/303(d) assessment prior to the reclassification, Gunns Run will be assessed as Category 4C, Impaired due to natural condition, no TMDL needed.

7.0. Public Participation

DEQ performed the assessment of the Butterwood Creek low DO natural condition in lieu of a TMDL. Therefore neither a TMDL Technical Advisory Committee (TAC) meeting nor a public meeting was involved. Public participation will occur during the next water quality standards triennial review process.

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Appendix A

Glossary

GLOSSARY

Note: All entries in italics are taken from USEPA (1998). All non-italicized entries are taken from MapTech (2002).

303(d). A section of the Clean Water Act of 1972 requiring states to identify and list water bodies that do not meet the states' water quality standards.

7Q10. The lowest streamflow for seven consecutive days that occurs on average once every ten years.

Ambient water quality. *Natural concentration of water quality constituents prior to mixing of either point or nonpoint source load of contaminants. Reference ambient concentration is used to indicate the concentration of a chemical that will not cause adverse impact on human health.*

Anthropogenic. *Pertains to the [environmental] influence of human activities.*

Background levels. *Levels representing the chemical, physical, and Bacterial conditions that would result from natural geomorphological processes such as weathering or dissolution.*

Best management practices (BMPs). *Methods, measures, or practices determined to be reasonable and cost-effective means for a landowner to meet certain, generally nonpoint source, pollution control needs. BMPs include structural and nonstructural controls and operation and maintenance procedures.*

Clean Water Act (CWA). *The Clean Water Act (formerly referred to as the Federal Water Pollution Control Act or Federal Water Pollution Control Act Amendments of 1972), Public Law 92-500, as amended by Public Law 96-483 and Public Law 97-117, 33 U.S.C. 1251 et seq. The Clean Water Act (CWA) contains a number of provisions to restore and maintain the quality of the nation's water resources. One of these provisions is section 303(d), which establishes the TMDL program.*

Concentration. *Amount of a substance or material in a given unit volume of solution; usually measured in milligrams per liter (mg/L) or parts per million (ppm).*

Confluence. The point at which a river and its tributary flow together.

Contamination. *The act of polluting or making impure; any indication of chemical, sediment, or Bacterial impurities.*

Designated uses. *Those uses specified in water quality standards for each waterbody or segment whether or not they are being attained.*

Dilution. *The addition of some quantity of less-concentrated liquid (water) that results in a decrease in the original concentration.*

Direct runoff. *Water that flows over the ground surface or through the ground directly into streams, rivers, and lakes.*

Discharge. *Flow of surface water in a stream or canal, or the outflow of groundwater from a flowing artesian well, ditch, or spring. Can also apply to discharge of liquid effluent from a facility or to chemical emissions into the air through designated venting mechanisms.*

Discharge permits (under VPDES). *A permit issued by the U.S. EPA or a state regulatory agency that sets specific limits on the type and amount of pollutants that a municipality or industry can discharge to a receiving water; it also includes a compliance schedule for achieving those limits. The permit process was established under the National Pollutant Discharge Elimination System, under provisions of the Federal Clean Water Act.*

Domestic wastewater. *Also called sanitary wastewater, consists of wastewater discharged from residences and from commercial, institutional, and similar facilities.*

Drainage basin. *A part of a land area enclosed by a topographic divide from which direct surface runoff from precipitation normally drains by gravity into a receiving water. Also referred to as a watershed, river basin, or hydrologic unit.*

Effluent. *Municipal sewage or industrial liquid waste (untreated, partially treated, or completely treated) that flows out of a treatment plant, septic system, pipe, etc.*

Effluent limitation. *Restrictions established by a state or EPA on quantities, rates, and concentrations in pollutant discharges.*

Existing use. *Use actually attained in the waterbody on or after November 28, 1975, whether or not it is included in the water quality standards (40 CFR 131.3).*

GIS. Geographic Information System. A system of hardware, software, data, people, organizations and institutional arrangements for collecting, storing, analyzing and disseminating information about areas of the earth. (Dueker and Kjerne, 1989)

Hydrologic cycle. *The circuit of water movement from the atmosphere to the earth and its return to the atmosphere through various stages or processes, such as precipitation, interception, runoff, infiltration, storage, evaporation, and transpiration.*

Hydrology. *The study of the distribution, properties, and effects of water on the earths surface, in the soil and underlying rocks, and in the atmosphere.*

In situ. *In place; in situ measurements consist of measurements of components or processes in a full-scale system or a field, rather than in a laboratory.*

Margin of safety (MOS). *A required component of the TMDL that accounts for the uncertainty about the relationship between the pollutant loads and the quality of the*

receiving waterbody (CWA section 303(d)(1)(C)). The MOS is normally incorporated into the conservative assumptions used to develop TMDLs (generally within the calculations or models) and approved by EPA either individually or in state/EPA agreements. If the MOS needs to be larger than that which is allowed through the conservative assumptions, additional MOS can be added as a separate component of the TMDL (in this case, quantitatively, a TMDL = LC = WLA + LA + MOS).

Mean. The sum of the values in a data set divided by the number of values in the data set.

MGD. Million gallons per day. A unit of water flow, whether discharge or withdraw.

Monitoring. *Periodic or continuous surveillance or testing to determine the level of compliance with statutory requirements and/or pollutant levels in various media or in humans, plants, and animals.*

Narrative criteria. *Nonquantitative guidelines that describe the desired water quality goals.*

National Pollutant Discharge Elimination System (NPDES). *The national program for issuing, modifying, revoking and re-issuing, terminating, monitoring, and enforcing permits, and imposing and enforcing pretreatment requirements, under sections 307, 402, 318, and 405 of the Clean Water Act.*

Natural waters. *Flowing water within a physical system that has developed without human intervention, in which natural processes continue to take place.*

Non-point source. *Pollution that originates from multiple sources over a relatively large area. Nonpoint sources can be divided into source activities related to either land or water use including failing septic tanks, improper animal-keeping practices, forest practices, and urban and rural runoff.*

Numeric targets. *A measurable value determined for the pollutant of concern, which, if achieved, is expected to result in the attainment of water quality standards in the listed waterbody.*

Organic matter. *The organic fraction that includes plant and animal residue at various stages of decomposition, cells and tissues of soil organisms, and substances synthesized by the soil population. Commonly determined as the amount of organic material contained in a soil or water sample.*

Peak runoff. *The highest value of the stage or discharge attained by a flood event; also referred to as flood peak or peak discharge.*

Permit. *An authorization, license, or equivalent control document issued by EPA or an approved federal, state, or local agency to implement the requirements of an environmental regulation; e.g., a permit to operate a wastewater treatment plant or to operate a facility that may generate harmful emissions.*

Point source. *Pollutant loads discharged at a specific location from pipes, outfalls, and conveyance channels from either municipal wastewater treatment plants or industrial waste treatment facilities. Point sources can also include pollutant loads contributed by tributaries to the main receiving water stream or river.*

Pollutant. *Dredged spoil, solid waste, incinerator residue, sewage, garbage, sewage sludge, munitions, chemical wastes, Bacterial materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt, and industrial, municipal, and agricultural waste discharged into water. (CWA section 502(6)).*

Pollution. *Generally, the presence of matter or energy whose nature, location, or quantity produces undesired environmental effects. Under the Clean Water Act, for example, the term is defined as the man-made or man-induced alteration of the physical, Bacterial, chemical, and radiological integrity of water.*

Public comment period. *The time allowed for the public to express its views and concerns regarding action by EPA or states (e.g., a Federal Register notice of a proposed rule-making, a public notice of a draft permit, or a Notice of Intent to Deny).*

Raw sewage. *Untreated municipal sewage.*

Receiving waters. *Creeks, streams, rivers, lakes, estuaries, ground-water formations, or other bodies of water into which surface water and/or treated or untreated waste are discharged, either naturally or in man-made systems.*

Restoration. *Return of an ecosystem to a close approximation of its presumed condition prior to disturbance.*

Riparian areas. *Areas bordering streams, lakes, rivers, and other watercourses. These areas have high water tables and support plants that require saturated soils during all or part of the year. Riparian areas include both wetland and upland zones.*

Riparian zone. *The border or banks of a stream. Although this term is sometimes used interchangeably with floodplain, the riparian zone is generally regarded as relatively narrow compared to a floodplain. The duration of flooding is generally much shorter, and the timing less predictable, in a riparian zone than in a river floodplain.*

Runoff. *That part of precipitation, snowmelt, or irrigation water that runs off the land into streams or other surface water. It can carry pollutants from the air and land into receiving waters.*

Slope. *The degree of inclination to the horizontal. Usually expressed as a ratio, such as 1:25 or 1 on 25, indicating one unit vertical rise in 25 units of horizontal distance, or in a decimal fraction (0.04), degrees (2 degrees 18 minutes), or percent (4 percent).*

Stakeholder. Any person with a vested interest in assessment of natural condition or TMDL development.

Standard. In reference to water quality (e.g. pH 6 – 9 SU limit).

Storm runoff. *Storm water runoff, snowmelt runoff, and surface runoff and drainage; rainfall that does not evaporate or infiltrate the ground because of impervious land surfaces or a soil infiltration rate lower than rainfall intensity, but instead flows onto adjacent land or into waterbodies or is routed into a drain or sewer system.*

Streamflow. *Discharge that occurs in a natural channel. Although the term "discharge" can be applied to the flow of a canal, the word "streamflow" uniquely describes the discharge in a surface stream course. The term "streamflow" is more general than "runoff" since streamflow may be applied to discharge whether or not it is affected by diversion or regulation.*

Stream restoration. *Various techniques used to replicate the hydrological, morphological, and ecological features that have been lost in a stream because of urbanization, farming, or other disturbance.*

Surface area. *The area of the surface of a waterbody; best measured by planimetry or the use of a geographic information system.*

Surface runoff. *Precipitation, snowmelt, or irrigation water in excess of what can infiltrate the soil surface and be stored in small surface depressions; a major transporter of nonpoint source pollutants.*

Surface water. *All water naturally open to the atmosphere (rivers, lakes, reservoirs, ponds, streams, impoundments, seas, estuaries, etc.) and all springs, wells, or other collectors directly influenced by surface water.*

Topography. *The physical features of a geographic surface area including relative elevations and the positions of natural and man-made features.*

Total Maximum Daily Load (TMDL). *The sum of the individual wasteload allocations (WLAs) for point sources, load allocations (LAs) for nonpoint sources and natural background, plus a margin of safety (MOS). TMDLs can be expressed in terms of mass per time, toxicity, or other appropriate measures that relate to a state's water quality standard.*

Tributary. *A lower order-stream compared to a receiving waterbody. "Tributary to" indicates the largest stream into which the reported stream or tributary flows.*

Variance. A measure of the variability of a data set. The sum of the squared deviations (observation – mean) divided by (number of observations) – 1.

DCR. Department of Conservation and Recreation.

DEQ. Virginia Department of Environmental Quality.

VDH. Virginia Department of Health.

Wastewater. *Usually refers to effluent from a sewage treatment plant. See also* ***Domestic wastewater****.*

Wastewater treatment. *Chemical, Bacterial, and mechanical procedures applied to an industrial or municipal discharge or to any other sources of contaminated water to remove, reduce, or neutralize contaminants.*

Water quality. *The Bacterial, chemical, and physical conditions of a waterbody. It is a measure of a waterbody's ability to support beneficial uses.*

Water quality criteria. *Levels of water quality expected to render a body of water suitable for its designated use, composed of numeric and narrative criteria. Numeric criteria are scientifically derived ambient concentrations developed by EPA or states for various pollutants of concern to protect human health and aquatic life. Narrative criteria are statements that describe the desired water quality goal. Criteria are based on specific levels of pollutants that would make the water harmful if used for drinking, swimming, farming, fish production, or industrial processes.*

Water quality standard. *Law or regulation that consists of the beneficial designated use or uses of a waterbody, the numeric and narrative water quality criteria that are necessary to protect the use or uses of that particular waterbody, and an antidegradation statement.*

Watershed. *A drainage area or basin in which all land and water areas drain or flow toward a central collector such as a stream, river, or lake at a lower elevation.*